Scientific Research Publishing

Journal of High Energy Physics, Gravitation and Cosmology, 2025, 11(1), 168-182
https://www.scirp.org/journal/jhepgc
ISSN Online: 2380-4335
ISSN Print: 2380-4327

Time Definition Using the Extrinsic Universe: Expanding the Big Bang Theory

Yuri Nunes Silva

Universidade de Sao Paulo PMT-EPUSP, Sao Paulo, Brazil
Email: yuri@bdgj.com.br

How to cite this paper: Silva, Y.N. (2025) Time Definition Using the Extrinsic Universe: Expanding the Big Bang Theory. *Journal of High Energy Physics, Gravitation and Cosmology*, **11**, 168-182.
https://doi.org/10.4236/jhepgc.2025.111014

Received: October 30, 2024
Accepted: January 23, 2025
Published: January 26, 2025

Abstract

This paper aims to define the concept of time and justify its properties within the universal context, shedding new light on the nature of time. By employing the concept of the extrinsic universe, the paper explains the observable universe as the three-dimensional surface of a four-dimensional 3-sphere (hypersphere), expanding at the speed of light. This expansion process gives rise to what we perceive as time and its associated aspects, providing a novel interpretation of time as a geometric property emerging from the dynamics of the universe's expansion. The work offers insights into how this extrinsic perspective can address phenomena such as the universe's accelerated expansion and dark matter, aligning the model with current observational data.

Keywords

Extrinsic Universe, Time: Origin and Nature, Cosmology: Universe Expansion, Dark Energy, and Dark Matter

1. Introduction

Just as the surface of a three-dimensional sphere is a two-dimensional manifold (2-sphere), the surface of a four-dimensional sphere is a three-dimensional manifold (3-sphere), providing the ideal framework to extend our understanding of time. Time is often treated as a scalar quantity in physical calculations, but a more robust definition of its nature, the processes involved in its emergence, and the consequences of its structure have remained elusive.

In the extrinsic universe model proposed by [1], time is explained as the natural outcome of the universe's expansion at the speed of light. Since the universe is modeled as a 3-sphere hypersphere, this expansion occurs along the radius, with the surface extending outward in the direction of its normal. As spatial volume flows through the surface in the opposite direction, time emerges from this phenomenon. Mathematically, this is described using both extrinsic and intrinsic geometry. The three-dimensional surface we inhabit is intrinsic, while the exterior, viewed from an imaginative standpoint as an observer outside the universe, presents the 3-sphere hypersphere embedded in a four-dimensional, atemporal space.

In the intrinsic universe, where we reside, the time we perceive is proper time, while external time is observed from universe outside. Conceptually, in the present, both proper time and external time coincide. However, all observable events in the universe occur in proper time, and external time is accessible to us only through calculation. The speed of light (c) never changes in proper time of intrinsic universe, preserving consistency with relativity theory.

It is important to emphasize that the concept of proper time and external time being discussed here refers to the universe as a whole or specifically in regions free from the influence of matter. In the vicinity of a massive object, there exists the proper time related to the proximity of the massive object. In the vicinity of a massive object, time passes more slowly than far away, at this point it acts by causing drag, slowing the expansion of the radius, this is cumulative and after a long period of time it forms a deformed hypersphere, forming a cap in the direction of the origin opposite to the radius. What we refer to as dark matter is essentially this cap.

Seen universe extrinsic, the radius of the hypersphere expands in a normal direction, but for us in intrinsic universe a portion of space, fluxes through the surface of the hypersphere in opposite direction of normal. For this reason, in intrinsic universe time has opposite signal than signal of space dimensions, preserving Relativity theory.

The expansion of universe is accelerating [2], considering the radius is $c \cdot t$ and that c is constant in intrinsic universe the pass of time is speeding. This accelerating is proportional of Ricci scalar of the universe extrinsic driving the "want" to expand. This explains the inflation period but discards deaccelerating period.

While the idea of envisioning the universe without time is challenging for us, as we are accustomed to visualizing everything in a sequential, chronological order, this model provides a natural and elegant explanation for complex phenomena. The extrinsic universe framework offers simple yet powerful insights into the expansion of the universe, the acceleration of this expansion, and the nature of dark matter. All these phenomena are mathematically demonstrated within this model and align with observational data.

2. Formulation

To support the extrinsic universe model, was used orthonormal space of four spatial dimensions in the atemporal R^4 space [1]. In this orthonormal R^4 space, we mathematically describe a 3-sphere hypersphere (rΘΦΨ) whose surface represents our observable universe, which is referred to as the intrinsic universe. While the entire set of R^4 and the 3-sphere will be referred to as the extrinsic universe and represent our universe seen from out side.

The components of R^4 are given by $X^n \mid n=1$ to 4. The contravariant system is described by $u^0 = r$, $u^1 = r \cdot \Theta$, $u^2 = r \cdot \Phi$, and $u^3 = r \cdot \Psi$. The position vector is given by $\boldsymbol{S}\left(X^1 i, X^2 j, X^3 k, X^4 l\right)$, and the unit covariant basis is given by $e_\mu = \partial \boldsymbol{S} / \partial u^\mu \mid \mu = 0$ to 3, with the covariant basis given by $a_0 = \partial \boldsymbol{S} / \partial r$, $a_1 = \partial \boldsymbol{S} / \partial \Theta$, $a_2 = \partial \boldsymbol{S} / \partial \Phi$, and $a_3 = \partial \boldsymbol{S} / \partial \Psi$. The surface of the 3-sphere respects $r^2 = \sum_{n=1}^{4} \left(X^n\right)^2$, defined by the relation:

$$\begin{aligned} X^1 &= r \sin(\Theta) \sin(\Phi) \cos(\Psi) \\ X^2 &= r \sin(\Theta) \sin(\Phi) \sin(\Psi) \\ X^3 &= r \sin(\Theta) \cos(\Phi) \\ X^4 &= r \cos(\Theta) \end{aligned} \tag{1}$$

The radius r of this 3-sphere hypersphere is what was formulated in way to explain the nature time and phenomena currently explained in an exotic way. With a simple approach all solutions appear naturally. The radius $\boldsymbol{r}$ is equal to $\boldsymbol{c} \cdot t$, where $\boldsymbol{c}$ is the velocity of light vector and t is the time elapsed since the beginning of the universe with the Big Bang. The 3-sphere surface expanding in velocity of light and from this process time emerges. Thus, the observable universe lies in the intrinsic geometry of the surface of the described 3-sphere hypersphere, which possesses three independent angles and, together with the radius, forms the three-dimensional system plus time of the intrinsic universe.

In the structure of a pseudo-Riemannian manifold, the negative sign associated with a specific dimension, such as time in relativity, reflects the qualitative distinction of this coordinate relative to the others. Mathematically, in a spatial manifold that moves or expands, this movement occurs along an axis of displacement perceived as a temporal coordinate. This temporal coordinate does not constitute part of the spatial manifold's structure but functions as an extra coordinate that crosses the manifold's surface, possibly representing a position vector or simply existing as a non-participating coordinate.

This geometric relationship can be interpreted as a characteristic of the pseudo-Riemannian metric, which features a signature where one dimension, such as time, contributes negatively in the quadratic form. This reflects the geometric distinction between temporal and spatial coordinates, with time serving as the dimension that parameterises the evolution of the manifold in spacetime. While the spatial coordinates define the surface of the manifold and can be combined through rotations, the temporal coordinate operates in a qualitatively distinct manner, ensuring causality and guiding the expansion or displacement of the manifold [3] [4].

Additionally, this interpretation suggests that the temporal coordinate acts as an external support for the structure of the spatial manifold, aligned with the direction of global displacement. However, other coordinates could, in principle, play a similar role depending on the metric and geometric context. In physical spacetime, time stands out due to its relationship with causality and the observed orientation of the spacetime manifold. [4] [5] Thus, the negative sign associated with time in the metric is not merely a mathematical convention but an expression of the unique geometric role of this coordinate.

This makes it evident that the inverted sign relative to the spatial coordinates arises from the non-participation of this coordinate in the spatial manifold's structure, instead crossing its surface and interacting with its normal. Other hidden coordinates, which remain stationary under similar conditions, might also exhibit a sign opposite to that of the spatial manifold. Furthermore, the term "space-time manifold" is not entirely appropriate in this context, as it constitutes a pseudo-manifold rather than a true manifold. This distinction arises because a manifold is defined as the set of coordinates that form a n-surface, and the temporal coordinate does not participate in this n-surface, but rather crosses and merely exists as an extra coordinate that does not participate in it.

The line elements describing the surface of this 3-sphere, describe our universe seen from out side are shown in equations below and are used to construct the metric tensor of the extrinsic universe.

$$dS^2 = -dr^2 + r^2\left(\frac{du^1}{r}\right)^2 + r^2\sin^2\left(\frac{u^1}{r}\right)\left(\frac{du^2}{r}\right)^2 + r^2\sin^2\left(\frac{u^1}{r}\right)\sin^2\left(\frac{u^2}{r}\right)\left(\frac{du^3}{r}\right)^2$$

$$dS^2 = -c^2\left(du^0\right)^2 + \left(du^1\right)^2 + \sin^2\left(\frac{u^1}{r}\right)\left(du^2\right)^2 + \sin^2\left(\frac{u^1}{r}\right)\sin^2\left(\frac{u^2}{r}\right)\left(du^3\right)^2 \tag{2}$$

$$dS^2 = \begin{pmatrix} -c^2 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & \sin^2\left(\frac{u^1}{r}\right) & 0 \\ 0 & 0 & 0 & \sin^2\left(\frac{u^1}{r}\right)\sin^2\left(\frac{u^2}{r}\right) \end{pmatrix} du^\mu du^\nu$$

where c is the constant component of du^0 and represents the dimensionless speed of light number.

The Minkowski metric tensor $\eta_{\mu\nu}$ is obtained in the tangent space to the surface of the hypersphere, where the radius forms the axis connecting the origin and the surface (past) and extends outward from the surface (future). The intrinsic universe is therefore only the surface, with boundaries in both the past and the future, and is perceived as the tangent space to that surface [1].

$$dS^2 = -\left(du_0\right)^2 + \left(du_1\right)^2 + \left(du_2\right)^2 + \left(du_3\right)^2$$

$$\eta_{\mu\nu} = \begin{pmatrix} -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \tag{3}$$

The flat spacetime geometry within the intrinsic universe can be deformed according to general relativity, as described by the relativistic equations [6]. In this context, the η_{00} component of the metric tensor, associated with time, carries a sign opposite to that of the space-related components. This distinction arises because the time coordinate does not form part of the 3-sphere manifold itself but rather intersects and crosses through it.

In the intrinsic universe of the 3-sphere hypersphere, the unit covariant basis behaves as an orthonormal three-dimensional system plus time, deforming according to the equations of relativity. In extrinsic geometry, the normal to the surface of the hypersphere points outward $\hat{\boldsymbol{n}}$, in the same direction as the radial expansion $r = c \cdot t$. The expansion of the hypersphere within a four-dimensional volume $\boldsymbol{F}$ results in a spatial flux against the surface. This flux passes through the surface in the opposite direction to the normal, and time emerges from this process.

The spatial flux crossing the surface of hypersphere 3-sphere without deformation is calculated as [3]:

$$\boldsymbol{F} = \int_S -r \cdot \hat{\boldsymbol{n}} \mathrm{d}A \tag{4}$$

The normal vector of the 3-sphere without deformation is a vector perpendicular to the surface at each point. For surfaces defined by a function $P(x_1, x_2, x_3, x_4) = 0$, the normal vector is given by the gradient of P:

$$\boldsymbol{n} = \nabla P \tag{5}$$

Therefore, the unit normal vector is:

$$\hat{\boldsymbol{n}} = \frac{(2x_1, 2x_2, 2x_3, 2x_4)}{2r} = \left(\frac{x_1}{r}, \frac{x_2}{r}, \frac{x_3}{r}, \frac{x_4}{r}\right) \tag{6}$$

The unit normal vector $\hat{n}$ at a specific point of the 3-sphere hypersphere is:

$$\hat{\boldsymbol{n}} = (\sin\Theta \sin\Phi \cos\Psi, \sin\Theta \sin\Phi \sin\Psi, \sin\Theta \cos\Phi, \cos\Theta) \tag{7}$$

The area element $\mathrm{d}A$ in spherical coordinates on the 3-sphere hypersphere is:

$$\mathrm{d}A = r^3 \sin^2\Theta \sin\Phi \mathrm{d}\Theta \mathrm{d}\Phi \mathrm{d}\Psi \tag{8}$$

The dot product $-\boldsymbol{r} \cdot \hat{\boldsymbol{n}}$ is:

$$-\boldsymbol{r} \cdot \hat{\boldsymbol{n}} = -r(1) = -r = -c \cdot t \tag{9}$$

The surface integral is:

$$\boldsymbol{F} = \iint_V -r \cdot r^3 \sin^2\Theta \sin\Phi \mathrm{d}\Theta \mathrm{d}\Phi \mathrm{d}\Psi \tag{10}$$

Thus:

$$\boldsymbol{F} = -r^4 \cdot \frac{\pi}{2} \cdot 2 \cdot 2\pi = -2\pi^2 r^4 \tag{11}$$

The calculations above demonstrate that the opposite sign of the time-related component naturally arises from the proposed model, and it also indicates the direction time is fluxing. It also shows the four-dimensional spatial volume of R^4, $-2\pi^2 r^4$, which crosses the surface of the 3-sphere hypersphere due to its expansion. This demonstration is valid for an undeformed universe. When deformations occur on the surface of the 3-sphere hypersphere, the normal vector shifts relative to the R^4 spatial flux, slowing the passage of time by decreasing the volume that crosses the surface [1].

At this point, it is necessary to reconsider the definition of the hypersphere's radius. If $\boldsymbol{c} \cdot t$ is the radiu expansion, how does acceleration of the universe expansion in? The time we observe in the intrinsic universe is the proper time. However, when observed externally in the extrinsic universe, time will be perceived differently. Intrinsically, the radius of the universe will always be $\boldsymbol{c} \cdot t$ and c will always remain constant. The passage of time varies, compressing and appearing faster as the universe expands. Taking our current time of 13.8 billion years as the external time, without contraction, for any earlier time (t), considering the radius at τ (t as proper time) as a contraction of the present radius, using only known relations from relativity theory, was written the equation below.

$$r_{\text{present}} = \gamma \cdot r(\tau) \therefore \gamma = \frac{r_{\text{present}}}{r(\tau)} \tag{12}$$

Since τ is the proper time, $\mathbf{t}$ is referring to the external time.

$$\tau = \mathbf{t} \cdot \gamma \quad \therefore \tau = \mathbf{t} \cdot \frac{r_{\text{present}}}{r(\tau)} = \frac{\mathbf{t} \cdot r_{\text{present}}}{c \cdot \tau} \tag{13}$$

$$\tau = \sqrt{\frac{\mathbf{t} \cdot r_{\text{present}}}{c}} \tag{14}$$

This equation shows how proper time progressed from our perspective, the proper time of the intrinsic universe, or the observable universe. As expected, there was a strong initial expansion that rapidly attenuated, described in the literature as the inflationary era of the universe. Inflation is an observable phenomenon in proper time, through the observable universe (intrinsic universe), as shown in **Figure 1** [1].

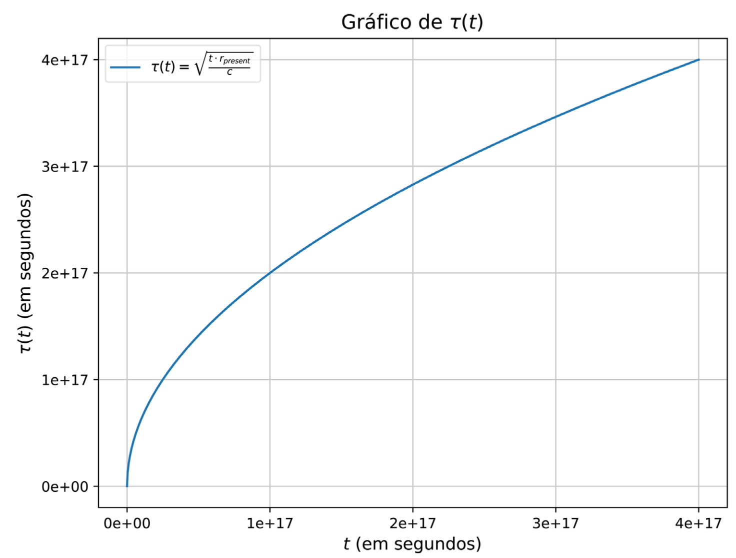

Figure 1. Graph of $\tau(t)$ with constant r_{present} and c.

2.1. Expansion of the Universe

One of the key phenomena observed in the universe is its expansion, first calculated by Edwin Hubble, who proposed a constant named after him, measuring the expansion rate of the universe. Currently, the Hubble constant (H_0) is estimated between 67 to 74 km/s per Megaparsec (Mpc) [2], varying based on the measurement methodology. The expansion of the universe is predicted in this work, and we present a new interpretation using the Extrinsic Universe model. Given that the radius of the 3-sphere hypersphere expands with a radius equal to $c \cdot t$, the consequence is the expansion of the three-dimensional surface of the intrinsic universe. The Hubble constant measures the speed at which two distant points at a distance of one Megaparsec (Mpc) move away from each other. Knowing that the perimeter of the 3-sphere hypersphere is $2 \cdot \pi \cdot r$, where $r = c \cdot t$ and t is cosmological time, r is thus equal to 13.82 billion light-years according to the Planck 2018 results [2]. One Mpc corresponds to 3,261,563.78 light-years [7]. Below, P represents the perimeter of the 3-sphere between two points, Θ is the angle between the position vectors at these points, and r is the radius of the 3-sphere. [1] These relationships are expressed as follows:

$$P = \Theta \cdot r$$

The Hubble parameter H, which describes the rate of expansion of the universe, can then be derived using the relationship:

$$H = \frac{\Theta \cdot r}{dt}$$

By substituting $r = c \cdot t$, we obtain:

$$H = \Theta \cdot c \cdot \frac{t}{dt}$$

Rewriting H in terms of the perimeter in megaparsecs (P_{Mpc}) yields:

$$H = \frac{P_{Mpc}}{c \cdot t} \cdot c$$

Finally, for the present time t_0, we define the Hubble constant H_0 as:

$$H_0 = \frac{P_{Mpc}}{t_0} \Rightarrow H_0 = \frac{P_{Mpc}}{t_{\text{present}}}$$

One megaparsec (1 Mpc) is equivalent to 3.083565553 × 10^{19} kilometers, while 13.82 billion years corresponds to 4.3582752 × 10^{17} seconds.

$$H_0 = \frac{3.083565553 \cdot 10^{19}}{4.3582752 \cdot 10^{17}} \Rightarrow H_0 = 70.75 \text{ km/s Mpc}^{-1}$$

This formulation connects the geometric properties of the hypersphere 3-sphere with the cosmological parameters of the expanding universe, illustrating a clear relationship between geometry and the dynamics of cosmic expansion.

The result obtained falls within the range of experimental measurements. Furthermore, by considering increasingly precise values for the age of the universe, a more accurate Hubble constant can be obtained. However, the expansion of the universe is not uniform, being influenced and slowed in regions with significant spacetime deformations on the surface of the 3-sphere hypersphere. In the context of the Extrinsic Universe, this expansion is directly related to the time coordinate, and the calculations assume a 3-sphere hypersphere without deformations. This result supports the proposed model.

2.2. Acceleration of the Universe Expansion

The acceleration of the universe's expansion is attributed to the presence of dark energy as described by the ΛCDM theory [2] [8]. This work presents a geometric approach linked to the curvature of the 3-sphere hypersphere in the Extrinsic Universe to explain this acceleration.

Analogous to other phenomena, it is intuitive that spacetime has an "elastic" resistance to curvature. The gravitational constant reflects spacetime's tendency to return to a flat orthonormal shape, where the Ricci scalar and tensor are zero, assuming progressively greater values in curved spacetime [3]. The Ricci tensor was used via the Ricci flow to solve the Poincaré Conjecture by Grigori Perelman using his surgery technique. Ricci flow is a mathematical tool that smooths the curvature of a n-dimensional manifold and uses the Ricci tensor with a negative sign.

The hypersphere proposed in this work has non-zero values for the Ricci scalar and tensor, which we use to calculate the value of Λ while ignoring the effects of dark matter and baryonic matter. Geometrically, the Ricci tensor and scalar represent the manifold's "desire" to become orthonormal-flat again.

In the Extrinsic Universe, as the radius of the hypersphere increases, both the Ricci tensor and scalar tend toward zero. This positive value provides the energy for the observed acceleration. This perspective suggests that accelerated expansion emerges from changes in spacetime geometry on cosmological scales. Analyzing the universe extrinsically and disregarding the effect of matter, the value of Λ is derived purely from the spatial deformation of the 3-sphere hypersphere. The following equation is proposed to relate Λ to the spatial side of Einstein's field equation for the Extrinsic Universe [1].

Einstein sought the contracted Bianchi identity to describe spacetime and maintain energy-momentum conservation. The covariant derivative of the contracted Bianchi identity is zero, as is the covariant derivative of the energy-momentum tensor, satisfying the energy-momentum conservation law essential for the perfect formulation of general relativity [3].

This work proposes that $\Lambda g_{\mu\nu}$ should equal the relationship derived from the contracted Bianchi identity, describing the Extrinsic Universe's spacetime. The tensors and the scalar in this case represent the universe and are bolded in the equation to differentiate from those describing other spacetime curvatures, like black holes or stars. Thus, the Einstein equation for general relativity becomes [1]:

$$\begin{aligned} &R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu} \quad \text{Original} \\ &R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} + \boldsymbol{R}_{\boldsymbol{\mu\nu}} - \frac{1}{2} \boldsymbol{R} g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu} \quad \text{Proposed} \end{aligned} \tag{15}$$

Considering an undeformed hypersphere, it is possible to calculate the cosmological constant without the influence of dark and baryonic matter, and compare it with the measurements from the Planck 2018 results [2].

$$\boldsymbol{R}_{\mu\nu} = \boldsymbol{R} g_{\mu\nu} \tag{16}$$

Using the above relationship, the bolded Ricci tensor can be replaced in the proposed equation by $\boldsymbol{R} g_{\mu\nu}$ due to the particular case of the undeformed hypersphere.

$$\Lambda g_{\mu\nu} = \boldsymbol{R} g_{\mu\nu} - \frac{1}{2}\boldsymbol{R} g_{\mu\nu} \tag{17}$$

where, $\boldsymbol{R}_{\mu\nu}$ is the Ricci tensor for the universe, $\boldsymbol{R}$ is the Ricci scalar, $\boldsymbol{g}_{\mu\nu}$ is the metric tensor, and Λ is the cosmological constant.

$$\Lambda = \frac{1}{2}\boldsymbol{R} \tag{18}$$

The Ricci scalar $\boldsymbol{R}$ for the 3-sphere manifold case is given by equation below [9] [10]:

$$\boldsymbol{R} = \frac{6}{r^2} \tag{19}$$

$$\begin{aligned} &r = 13800000000 \cdot 3600 \cdot 24 \cdot 365 \cdot 299792458 \text{ m} \\ &\boldsymbol{R} = 3.524832286589 \cdot 10^{-52} \text{ m}^{-2} \\ &\Lambda = 1.7624 \cdot 10^{-52} \text{ m}^{-2} \end{aligned} \tag{20}$$

where r is the radius of the 3-sphere hypersphere in the Extrinsic Universe, in this case, 13.8 billion light-years converted into meters [1].

The result is very close to what was measured. Using the equation derived from Friedmann's equations [8] and the known values in Planck 2018 results [2], with $\Omega_\Lambda = 0.6889 \pm 0.0056$ and $H_0 = 67.66 \pm 0.42 \text{ km/s} \cdot \text{Mpc}^{-1}$ [2]:

$$\Lambda = 3\left(\frac{H_0}{c}\right)^2 \Omega_\Lambda \quad \Rightarrow \quad \Lambda = 1.1056 \cdot 10^{-52} \text{ m}^{-2} \tag{21}$$

This result was obtained by considering contributions from dark matter, baryonic matter, and dark energy, as reflected in the observational values of Ω_Λ and H_0. If $\Omega_\Lambda = 1$, all the universe's energy content would consist solely of dark energy. There would be no significant contribution from matter (dark or baryonic) or radiation. The repulsive nature of dark energy would be the sole influence on the universe's dynamics [11]. This is equivalent to the universe described in this work, located on the surface of a 3-sphere hypersphere with a radius equal to $\boldsymbol{c} \cdot t$. Let's recalculate using this condition, where $\Omega_\Lambda = 1$ and the Hubble constant H_0 calculated in this work $H_0 = 70.75 \text{ km/s} \cdot \text{Mpc}^{-1}$.

$$\Lambda = 3\left(\frac{H_0}{c}\right)^2 \quad \Rightarrow \quad \Lambda = 1.7594 \cdot 10^{-52} \text{ m}^{-2} \tag{22}$$

The value above is very close to the one calculated from the Ricci scalar for a 3-sphere described in the Extrinsic Universe. It is interesting to note how the acceleration of the universe expansion relates to radiu expansion. The acceleration, expressed through the Ricci tensor and scalar for the curvature of the 3-sphere hypersphere, is the energy that drives the universe's expansion, remaining in intrinsic universe the radiu equal $c \cdot t$, since what varies is the passage of time.

2.3. Dark Matter

Dark matter does not interact with electromagnetic radiation in a detectable way and is inferred through gravitational effects in various astronomical phenomena [12] [13]. The rotation curves of spiral galaxies show that the orbital velocity of stars remains nearly constant at large distances from the galactic center, which cannot be explained solely by visible luminous matter [14] [15]. Gravitational lensing observations reveal deviations in the light trajectory that can only be explained by the presence of additional unseen mass [16] [17]. Cosmological simulations indicate that dark matter is fundamental to the formation and evolution of large-scale structures in the universe [18] [19]. The absence of electromagnetic interaction explains the difficulty in directly detecting dark matter [20] [21]. The energy content of the universe is approximately distributed as follows: around 27% consists of dark matter, 5% of normal matter (baryons), and approximately 68% corresponds to dark energy [2] [22]. Although the exact nature of dark matter remains unknown, its existence is widely accepted due to robust indirect evidence and its importance in understanding modern cosmology [23] [24].

The developments presented in this work contribute to the understanding of dark matter. The deformation or curvature of spacetime that we observe, such as the nearly constant orbital velocity of stars at large distances from the galactic center, is dynamically constructed from a massive center in a small region of the expanding universe. As seen in this work, we approach the universe as the three-dimensional surface of a 3-sphere hypersphere whose radius is the time since the Big Bang up to the present, multiplied by the speed of light. The time we perceive is due to the movement at the speed of light of the universe against a spatial volume R^4, and this movement drives everything in the observable universe, or intrinsic universe. The solution to the phenomenon attributed to dark matter naturally arises in this context. A massive object that significantly deforms spacetime, so much so that near its Schwarzschild radius, the passage of time approaches zero for an external observer [3], will remain anchored at a fixed radius of the 3-sphere hypersphere in the Extrinsic Universe. Similar to a button on a cushion, the expansion of the universe around this object will continue, creating a pronounced depression, exceeding the deformation expected solely due to its mass. Beyond the anchored Schwarzschild radius, any point in the intrinsic universe experiencing deformation due to baryonic matter will cause time dilation, which will result in slower passage of time, forcing a depression in the surface of the 3-sphere hypersphere, contrary to the expansion. This will occur dynamically and cumulatively, potentially deviating from the center with the massive object's motion or the movement of the excess deformation created in this process.

The Schwarzschild metric for a massive object give the relation between massive object proper time and time for a observer a way [3] [25] [26]:

$$\mathrm{d}\tau_m = \sqrt{1-\frac{2GM}{c^2 r_m}}\mathrm{d}t \tag{23}$$

The radius r_m is the distance between the center of the object, which could be a black hole or the center of a galaxy, and a more distant orbital point. This distance is written in angular terms of the 3-sphere hypersphere of the extrinsic universe. Using the law of spherical cosines [27] [28], the distance between two points on a sphere relates the angle between two vectors on the sphere with the dot product:

Substituting r_m in the previous equation and using $\Theta \cdot c \cdot t$, where t should ideally be represented as τ_m to refer to the universe's proper time. However, for simplicity, it is kept as t. Here, c represents the speed of light, which, along with t, defines the radius of the 3-sphere hypersphere in the extrinsic universe. Θ represents the angular distance on the three-dimensional surface from the center of the massive object to any other point [1]:

$$\begin{aligned} r_s &= \frac{2GM}{c^2} \\ \mathrm{d}\tau_m &= \sqrt{1-\frac{r_s}{\Theta \cdot c \cdot t}}\mathrm{d}t \end{aligned} \tag{24}$$

Considering that this massive object appeared at some non-zero time in the intrinsic universe, it is assumed that there exists an initial r_0 for the hypersphere at which the object began to influence. The equation for the radius of the 3-sphere hypersphere, now depending on time and the three angles, must respect:

$$\begin{aligned} r_0 &= t_{r_0} \cdot c \\ \tau_m &= \int_{t_{r_0}}^{t} \sqrt{1-\frac{r_s}{\Theta \cdot c \cdot t}}\mathrm{d}t \end{aligned} \tag{25}$$

$$\tau_m = \Bigg|_{t_{r_0}}^{t_{\text{present}}} \left\{ \sqrt{t \cdot \left(t - \frac{r_s}{\Theta \cdot c}\right)} - \frac{r_s}{\Theta \cdot c} \cdot \ln\left[\sqrt{t} + \sqrt{\left(t - \frac{r_s}{\Theta \cdot c}\right)}\right]\right\} + t_{r_0}$$

complete equation :

$$\begin{aligned} \tau_m = & \left\{ \sqrt{t_{\text{present}} \cdot \left(t_{\text{present}} - \frac{r_s}{\Theta \cdot c}\right)} - \frac{r_s}{\Theta \cdot c} \cdot \ln\left[\sqrt{t_{\text{present}}} + \sqrt{\left(t_{\text{present}} - \frac{r_s}{\Theta \cdot c}\right)}\right]\right\} \\ & - \left\{ \sqrt{t_{r_0} \cdot \left(t_{r_0} - \frac{r_s}{\Theta \cdot c}\right)} - \frac{r_s}{\Theta \cdot c} \cdot \ln\left[\sqrt{t_{r_0}} + \sqrt{\left(t_{r_0} - \frac{r_s}{\Theta \cdot c}\right)}\right]\right\} + t_{r_0} \end{aligned} \tag{26}$$

The equation above describes how the surface of the 3-sphere hypersphere deforms over time under the influence of a constant massive object [1]. The spatial deformation caused by matter perfectly respects the theory of relativity. However, due to the curvature of the universe as an expanding hypersphere, this deformation becomes cumulative. Applying τ_m to calculate the orbital velocity of stars in the Milky Way using only baryonic matter and disregarding dark matter. To achieve this, was consider the time deformation calculated by $\tau_m / t_{\text{present}}$, where τ_m is the delayed time due to the accumulation of slower time passage in a region with a high concentration of baryonic matter, and t_{present} is the total cosmological time. The numerical integration was used on python and was consistent with the results of above equation [1].

Calculations based on data from the literature demonstrate that the $\tau_m / t_{\text{present}}$ describes the excess deformation attributed to dark matter, which is, in fact, a dynamic accumulation of time delay. This deformation impacts the 3-sphere hypersphere, forming a cap in the past direction due to the universe's expansion. When applied to determine the circular orbital velocity, results in values very close to those found in the literature, even though the circular orbital velocity is an approximation, see **Table 1**. For solving the integral, key data about luminous matter, the distance from the galactic center, and the formation time (t_{r_0}) of the mass accumulation are required. In the present time, this accumulation resulted in the supermassive black hole at the center and the galactic volume comprising the galaxy. As it is a dynamic process of galactic formation, depending on when it started, the accumulation of matter, and the relative motion of the galactic sphere concerning the galactic center, the result is dependent on precise data and adjustments, such as t_{r_0} and the amount of luminous matter in the orbital sphere [1].

Using the classical orbital velocity approximation, with acceleration derived from the Schwarzschild equations and the newly proposed local proper time calculated above. Here, M represents the mass, a is the acceleration, r_m is the radius between a point in the galactic sphere and the galactic center (often near a supermassive black hole), G is the gravitational constant, t is the total time until the present, c is the speed of light, τ is the local proper time, and v_{orbital} is the orbital velocity.

$$
\begin{aligned}
& M = \frac{a \cdot r_m^2}{G} \\
& \frac{\mathrm{d}\tau}{\mathrm{d}t} = \sqrt{1 - \frac{2 \cdot G \cdot a \cdot r_m^2}{c^2 \cdot r_m \cdot G}} \\
& \frac{\mathrm{d}\tau}{\mathrm{d}t} = \sqrt{1 - \frac{2 \cdot a \cdot r_m}{c^2}} \\
& a = \left(1 - \left(\frac{\tau}{t}\right)^2\right) \cdot \frac{c^2}{2 \cdot r_m} \\
& v_{\text{orbital}} = \sqrt{a \cdot r_m}
\end{aligned}
\tag{27}
$$

Below was calculating some orbital velocity with luminous mass, distance from galactic center and the time when the galactic mass start to influence the time dilatation.

1 [29] [30], 2 [31] [32] [33] [34] [35], 3 [36] [37], 4 [38] [39]

It is very important to note that the formation time is earlier than what the literature suggests. However, this remains an open question for many researchers. The deformation due to the accumulation of time delay can be used to better understand local groups and larger structures in the universe.

Table 1. Table comparing calculated orbital velocity with values from the literature. The calculations were performed using equation (26), considering the variables luminous mass, the time in the universe when time dilation began due to the mass accumulation, and the orbital radius.

Region	Luminous Mass	Formation t_{r_0}	Distance (r_m)	Calculated Orb. Vel.	Orb. Vel. Lit.	Reference
Andromeda (M31)	10% of 2×10^{42} kg	20MY	130kLY	266,477 m/s	260 km/s	1
Milky Way	15% of 1.84×10^{41} kg	20MY	26kLY	221,352 m/s	220 km/s	2
Outer Milky Way	15% of 3.44×10^{41} kg	20MY	900kLY	51,442 m/s	50 km/s	3
NGC 3198	8.95×10^{40} kg	50MY	156kLY	150,622 m/s	150 km/s	4

3. Conclusions

The best way to visualize the proposed extrinsic universe model is by imagining a soap bubble, where the intrinsic universe represents the surface of the bubble. It's important to remember that this surface is three-dimensional with three angles. Inside the bubble represents the past, while outside it corresponds to the future. As the radius increases with time, the bubble expands toward the future, allowing space to flow into the bubble, thus increasing its volume.

Similarly, as in a coiled steel sheet, the smaller the radius, the greater the tension to unwind it. In the soap bubble analogy, there is also this tension, which drives the acceleration of the universe expansion. If a point on the surface becomes trapped for some reason, a depression will form in the surface.

This work introduces a new model. The model aims to be as simple as possible, coherent with observational data, and faithful to current physical knowledge. It serves as a gateway for deeper developments, while always maintaining the mentioned principles. And this work brings the time definition and its nature, other works are working progress for different insights.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Nunes Silva, Y. (2024) Foundations for the Extrinsic Universe: Expanding Big Bang Universe Model.

[2] Planck Collaboration, *et al.* (2020) Planck 2018 Results. *Astronomy & Astrophysics*, **641**, A6.

[3] Misner, C.W., Thorne, K.S. and Wheeler, J.A. (1973) Gravitation. W. H. Freeman and Company.

[4] O'Neill, B. (1973) Semi-Riemannian Geometry: With Applications to Relativity. Academic Press.

[5] Hawking, S.W. and Ellis, G.F.R. (1973) The Large Scale Structure of Space-Time. Cambridge University Press. https://doi.org/10.1017/cbo9780511524646

[6] Schutz, B. (2009) A First Course in General Relativity. 2nd Edition, Cambridge University Press. https://doi.org/10.1017/cbo9780511984181

[7] Allen, C.W. (1973) Astrophysical Quantities. 3rd Edition, Athlone Press.

[8] Wald, R.M. (1984) General Relativity. University of Chicago Press. https://doi.org/10.7208/chicago/9780226870373.001.0001

[9] do Carmo, M.P. (1992) Riemannian Geometry. Birkhäuser.

[10] Lee, J.M. (2018) Introduction to Riemannian Manifolds. 2nd Edition, Springer.

[11] Weinberg, S. (2008) Cosmology. Oxford University Press.

[12] Bertone, G., Hooper, D. and Silk, J. (2005) Particle Dark Matter: Evidence, Candidates and Constraints. *Physics Reports*, **405**, 279-390. https://doi.org/10.1016/j.physrep.2004.08.031

[13] Trimble, V. (1987) Existence and Nature of Dark Matter in the Universe. *Annual Review of Astronomy and Astrophysics*, **25**, 425-472. https://doi.org/10.1146/annurev.astro.25.1.425

[14] Rubin, V.C., Thonnard, N. and Ford, W.K.J. (1980) Rotational Properties of 21 SC Galaxies with a Large Range of Luminosities and Radii, from NGC 4605 (R = 4 Kpc) to UGC 2885 (R = 122 Kpc). *The Astrophysical Journal*, **238**, 471-487. https://doi.org/10.1086/158003

[15] Sofue, Y. and Rubin, V. (2001) Rotation Curves of Spiral Galaxies. *Annual Review of Astronomy and Astrophysics*, **39**, 137-174. https://doi.org/10.1146/annurev.astro.39.1.137

[16] Clowe, D., Bradač, M., Gonzalez, A.H., Markevitch, M., Randall, S.W., Jones, C., *et al.* (2006) A Direct Empirical Proof of the Existence of Dark Matter. *The Astrophysical Journal*, **648**, L109-L113. https://doi.org/10.1086/508162

[17] Bartelmann, M. and Schneider, P. (2001) Weak Gravitational Lensing. *Physics Reports*, **340**, 291-472. https://doi.org/10.1016/s0370-1573(00)00082-x

[18] Springel, V., White, S.D.M., Jenkins, A., Frenk, C.S., Yoshida, N., Gao, L., *et al.* (2005) Simulations of the Formation, Evolution and Clustering of Galaxies and Quasars. *Nature*, **435**, 629-636. https://doi.org/10.1038/nature03597

[19] Davis, M., Efstathiou, G., Frenk, C.S. and White, S.D.M. (1985) The Evolution of Large-Scale Structure in a Universe Dominated by Cold Dark Matter. *The Astrophysical Journal*, **292**, 371-394. https://doi.org/10.1086/163168

[20] Jungman, G., Kamionkowski, M. and Griest, K. (1996) Supersymmetric Dark Matter. *Physics Reports*, **267**, 195-373. https://doi.org/10.1016/0370-1573(95)00058-5

[21] Bertone, G. and Tait, T.M.P. (2018) A New Era in the Search for Dark Matter. *Nature*, **562**, 51-56. https://doi.org/10.1038/s41586-018-0542-z

[22] Planck Collaboration, *et al.* (2016) Planck 2015 Results. XIII. Cosmological Parameters. *Astronomy & Astrophysics*, **594**, A13.

[23] Freese, K. (2017) Status of Dark Matter in the Universe. *International Journal of Modern Physics D*, **26**, Article ID: 1730012. https://doi.org/10.1142/s0218271817300129

[24] Garrett, K. and Duda, G. (2011) Dark Matter: A Primer. *Advances in Astronomy*, **2011**, Article ID: 968283. https://doi.org/10.1155/2011/968283

[25] Hartle, J.B. (2003) Gravity: An Introduction to Einstein's General Relativity. Addison-Wesley.

[26] Rindler, W. (2006) Relativity: Special, General, and Cosmological. 2nd Edition, Oxford University Press.

[27] Loney, S.L. (1895) Plane and Spherical Trigonometry. Cambridge University Press.

[28] Todhunter, I. (1886) Spherical Trigonometry: For the Use of Colleges and Schools. Macmillan and Co. Disponível em domínio público, Project Gutenberg e Internet Archive.

[29] Physics Today (2020) Analysis of the Dark Matter in Andromeda, Covering the Distribution of Mass and Flat Rotation Curve. American Institute of Physics.

[30] ESA (2019) Data from the Gaia Mission and Studies on the Rotational Velocities in the Andromeda Galaxy. European Space Agency.

[31] Sofue, Y., Honma, M. and Omodaka, T. (2009) Unified Rotation Curve of the Galaxy—Decomposition into De Vaucouleurs Bulge, Disk, Dark Halo, and the 9-Kpc Rotation Dip. *Publications of the Astronomical Society of Japan*, **61**, 227-236. https://doi.org/10.1093/pasj/61.2.227

[32] McMillan, P.J. (2011) Mass Models of the Milky Way. *Monthly Notices of the Royal Astronomical Society*, **414**, 2446-2457. https://doi.org/10.1111/j.1365-2966.2011.18564.x

[33] Bland-Hawthorn, J. and Gerhard, O. (2016) The Galaxy in Context: Structural, Kinematic, and Integrated Properties. *Annual Review of Astronomy and Astrophysics*, **54**, 529-596. https://doi.org/10.1146/annurev-astro-081915-023441

[34] Reid, M.J., Menten, K.M., Brunthaler, A., Zheng, X.W., Dame, T.M., Xu, Y., *et al.* (2014) Trigonometric Parallaxes of High Mass Star Forming Regions: The Structure and Kinematics of the Milky Way. *The Astrophysical Journal*, **783**, Article No. 130. https://doi.org/10.1088/0004-637x/783/2/130

[35] Kafle, P.R., Sharma, S., Lewis, G.F. and Bland-Hawthorn, J. (2012) Kinematics of the Stellar Halo and the Mass Distribution of the Milky Way Using Blue Horizontal Branch Stars. *The Astrophysical Journal*, **761**, Article No. 98. https://doi.org/10.1088/0004-637x/761/2/98

[36] University of California—Santa Cruz. Astronomers Find the Most Distant Stars in Our Galaxy Halfway to Andromeda. ScienceDaily, 2023. https://www.sciencedaily.com/releases/2023/01/230109191622.htm

[37] Center for Astrophysics|Harvard and Smithsonian (2023) The Most Distant Known Star in the Milky Way.

[38] Karukes, E.V. and Salucci, P. (2014) Modeling the Mass Distribution in the Spiral Galaxy NGC 3198. *Journal of Physics*: *Conference Series*, **566**, Article ID: 012008. https://doi.org/10.1088/1742-6596/566/1/012008

[39] Begeman, K.G., Sanders, R.H. and Van Albada, T.S. (2002) Mond Rotation Curves for Spiral Galaxies with Cepheid-Based Distances. *Astronomy and Astrophysics*, **395**, 511-524.